Peale (A. C.)

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DEPARTMENT OF THE INTERIOR—U. S. GEOLOGICAL SURVEY
J. W. POWELL, DIRECTOR

THE
NATURAL MINERAL WATERS
OF
THE UNITED STATES

BY

A. C. PEALE

presented by the author

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U.S. GEOLOGICAL SURVEY
J.W. POWELL, DIRECTOR.
MINERAL SPRING RESORTS
OF THE
UNITED STATES
by
A.C. PEALE
1892.
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
CANADA (BRITISH POSSESSIONS)
Scale


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MEXICO
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CONTENTS.

ILLUSTRATIONS

THE NATURAL MINERAL WATERS OF THE UNITED STATES.

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INTRODUCTION.

Aside from the geological interest attached to the subject of mineral waters the facts that within the limits of the United States there are between 8,000 and 10,000 mineral springs, and that the waters from nearly 300 are annually placed upon the market to the extent of over 21,000,000 gallons, at a valuation of nearly $5,000,000, show plainly that the subject is also one of considerable economic importance. That this importance is an increasing one is evident when a comparison of these figures is made with the figures for 1883, the first year they were compiled. The production then was 7,529,423 gallons, with a valuation of $1,119,603, and the total number of springs known to be utilized for commercial purposes was only 189.

Dr. John Bell was one of the first to write about the mineral springs of the United States, and when he made his list of them in 1831 he enumerated 21 in all. To-day the list of commercially used waters drawn from our mineral springs is nine times greater than the total number then known.

When individual localities are considered and comparisons are made between the present conditions and those of a relatively few years ago the same advance in importance and interest is evident. At Saratoga Springs, for instance, a place that has given its name to many mineral spring resorts from one end of the country to the other, 40 springs have been discovered in addition to the High Rock spring, which, first known to white people in 1767, had been known and utilized for its medicinal virtues long before that by the aboriginal inhabitants of the country. In Saratoga to-day we have a spa that rivals the best in Europe, where attention has been devoted to the subject of mineral waters for centuries. In Virginia and West Virginia, also, which together now have at least 150 known mineral springs, there were in 1831 only 7 springs catalogued. Of these the Bath Mineral spring, now Berkeley Springs, named after the celebrated English watering place, was known and slightly improved as a resort in 1777;

and the Greenbrier White Sulphur Springs, generally known simply as the "White Sulphur Springs," date their first improvement from the year 1778. These places are the prototypes of mineral spring resorts now found in almost every State of the Union.

Much remains, however, to be done before the scientific use of our mineral waters can be defined with that careful regard to their chemical composition and their therapeutic value which is so much to be desired.

HISTORY.

Inasmuch as the history of our country reaches back only to a comparatively recent date the written history of its mineral springs must of necessity also be a rather short one. Although many of our best known mineral waters were known to the Indians from earliest times, and traditions of their virtues were transmitted to their white successors, the time of the latter was too much occupied to allow of much attention being paid to them.

The history of mineral springs in general, however, dates from the most remote periods. The Egyptians, Arabians, Mohammedans, Greeks, Romans, and, in fact, all nations, have used mineral waters for medicinal purposes from time immemorial. Hippocrates, Aristotle, Herodotus, and even Homer wrote of them; temples dedicated to Æsculapius, the god of medicine, were erected near them; and they were made the sites of hospitals, medical schools, baths, and resorts for the diversion of the sick.

Pliny, in his Natural History, says of these waters: "They spring wholesome from the earth on every side, and in a thousand lands, the cold, the hot, the hot and cold together, as at Tarbellum (Dax), in Aquitania, or in the Pyrenees, where they are separated only by a small interval, or yet the warm and tepid, announcing relief to the sick, and flowing from the earth only for man, of all living things."

For five centuries mineral waters were almost the only medicines used in Rome. In their conquests of northern and western Europe the Romans sought the springs of the countries, and in the names Acqui, Aix or Aachen, Dax, etc., derived from the Latin *aqua*, we have testimony of the former celebrity of these towns as watering places. The reputation of many of them has descended to our own time. Among the Romans warm bathing was indulged in to excess, and at one time there were 800 thermæ in Rome. Many traces of these ancient Roman baths remain. They were buildings of great architectural beauty, grand and magnificent, adorned with statuary and mosaics, and among them the baths of Diocletian and the baths of Caracalla were the most celebrated.

In our practical day we have shorn the springs of the superstitions of the ancients, and the busy habits of modern times do not permit us to spend the time and elaborate preparation upon the bath that was

bestowed upon it in the luxurious days of imperial Rome. Although we no longer depend upon hearsay as to the efficacy of springs in the cure of disease, but have chemists analyze the waters, still the period of true scientific investigation of their properties reaches back only a few hundred years, and the therapeutic study, especially in our own country, will require many more years of patient labor.

The first work upon the quality and use of water that was printed in America treats of it from a therapeutical standpoint. It is entitled: The Curiosities of Common Water, or the Advantages thereof in Curing Cholera, Intemperance, and other Maladies, by John Smith, C. M. It was reprinted at Boston, Massachusetts, from the London edition of 1712, for Joseph Edwards, at the corner shop on the north side of Town House, in 1725. It calls special attention to the excellency of water as a drink, and enumerates its therapeutical attributes as follows: "It cures gout and hypochondriac melancholy; it benefits gravel and stone in the bladder; it makes the child grow strong in the womb, and increases the mother's milk; it stays hunger; for there was a certain crack-brained man who, at Leyden, when Dr. Carr resided in that university, pretended he could fast as long as Christ did; and it was found that he held out the term of forty days without eating any food, only he drank water and smoked tobacco." "Water is also of great use to strengthen weak children; it prevents swelling from bruises, sickness of the stomach, shortness of breath, and vomiting; it cures fluxes, consumption, flushes, colic, smallpox, etc." Although written one hundred and eighty-one years ago this is not excelled by the pretentious claims of any modern mineral spring circular.

Dr. John Bell was perhaps the first to write anything like a treatise on the mineral springs of the United States. In his Baths and Mineral Waters, published in 1831, part II is devoted to "a history of the chemical composition and medicinal properties of the chief mineral springs of the United States and Europe." He enumerated 21 localities for the United States, which list was increased to 181 in The Mineral and Thermal Springs of the United States and Canada, which he published in 1855. Dr. J. J. Moonman, in his Mineral Springs of North America and How to Reach Them, published in 1873, refers to or describes 171 springs. This was preceded by his Mineral Springs of the United States and Canada, published in 1867, and by several books relating to the Virginia springs published in 1837, 1846, 1855, 1857, and 1859. Dr. George E. Walton's Mineral Springs of the United States and Canada, etc. (third edition), published in 1883, mentions for the United States 279 localities. Drs. William Pepper, H. I. Bowditch, A. N. Bell, S. E. Chaillé, and Charles Dennison, as a committee of the American Medical Association, in 1880 made a very complete compilation, which included about 500 localities. Dr. A. N. Bell's Climatology and Mineral Waters of the United States, published during the latter part of 1885, enumerated 173 localities. Bul-

letin No. 32, published by the U. S. Geological Survey in 1886 (compiled by the writer), included 2,822 mineral spring localities (and 8,843 individual springs), 634 of which were utilized as resorts and 223 as sources of commercial mineral water. One of the most recent enumerations is by Dr. Judson Daland in the list appended to Gould's New Medical Dictionary. An examination of the many works relating to the springs of the separate States or individual spring resorts is not in place here.

What is now needed most in relation to our own springs is, first, a careful chemical examination of all our mineral waters. This examination should be made upon one plan for all the waters, if not by the same chemist in all cases. We have analyses to the number of a thousand or more made upon almost as many plans as there are chemists who made them. Many of the analyses also were made long before the spectroscope was known, and the waters should be examined in the light of recent advances in chemical knowledge. Until this is done we have no way of accurately comparing them with each other or with the well known waters of other countries.

We need, secondly, a careful therapeutic and clinical study of our mineral waters. Until more study is devoted to this subject our physicians will continue to send patients abroad, because they know that at the foreign resorts the patient is at once put under the care of one who has made a study of the effects of the waters and has mastered all the details of its use in the treatment of disease. There has been a great improvement, however, in this respect, in the sanitaria of the United States in the past ten years, and before long it is hoped that none will be obliged to go abroad for treatment at a mineral spring resort. Until that day we shall have to rely upon the comparison of our waters with those of foreign countries where the study of their effect has been carried on for years. This comparison, of course, is facilitated by our knowledge of the chemical composition of the waters. It is an interesting fact that mineral waters were used by the ancients for the same diseases to which they are applied to-day.

DEFINITION.

The definition of a mineral water will depend upon the point of view, whether it be that of the chemist, or that of the physician or dealer. In the strictest sense water, being an inorganic body, that is, a compound of definite chemical composition, is itself a mineral. Common usage has restricted the term to those waters that contain appreciable quantities of foreign matter.

As water may be considered the universal solvent, all waters in a certain sense must be mineral waters from a chemical standpoint. Even glass is to a small extent soluble in water. Absolutely pure water is a product of the laboratory alone, and rain water, which is the

purest natural water, acquires in its passage through the atmosphere small quantities of solid organic and inorganic matters, as well as ammonia, carbonic acid gas, and other gases.

As Daubeny says,[1] "the term mineral water in its most extended sense comprises every modification existing in nature of that universally diffused fluid, whether considered with reference to its sensible properties or to its action upon life."

From the standpoint of the physician a mineral water is any water that has an effect upon the human system, no matter how feebly mineralized it may be; that is, it is any water that possesses medicinal virtues, whether they be due to the presence of organic, inorganic, or gaseous contents, or to the principle of heat. This is the definition found in most works on mineral springs. Under this definition, therefore, would be included many waters that, from a chemical standpoint, might be considered very pure or chemically indifferent. Many of them are less highly mineralized than the ordinary potable waters of a great many localities; yet the fact that they have some specific effect from a medical point of view entitles them to consideration as mineral waters.

From the standpoint of the dealer in bottled mineral waters the definition has of course a very wide range. From his point of view all waters put upon the market for sale in bottles or barrels or in any other way, come under the head of mineral waters, and in collecting the statistics of the commercial aspect of the subject it has been found impossible to draw any definite line, either according to the mineralization of the water or the uses to which it is put. A number of the waters included, and of importance commercially, would be considered indifferent when viewed in the light of their chemical composition, but it must be remembered that some very pure waters have an undoubted therapeutical effect, and that chemical analysis, which is absolutely reliable only in its estimation of basic salts and acids, will not always explain the medicinal effect of a water, and that small quantities of some constituents are often more effective as remedial agents than others that are present in larger quantities. It is an undoubted fact that many springs which, upon chemical analysis of their waters, are found to be not so highly mineralized as the majority of potable waters, have acquired, and rightly, too, great reputations for their medicinal value. That their medicinal value is thus recognized and that they are sources of profit to their owners and also indirectly an addition to the wealth of their localities, seem sufficient reasons why they should be included under the head of mineral springs, from this commercial point of view.

[1] Sixth Report, British Association for the Advancement of Science 1836, p. 1.

ORIGIN OF MINERAL SPRINGS.

One of the first questions that presents itself is: whence comes the great quantity of water that is poured forth by mineral springs and seems to be unfailing in its supply, changing but little in most cases from day to day and from year to year. It is an undisputed fact that the water of all springs, mineral or otherwise, is meteoric in its origin; but for a long time, in fact for ages, the origin of springs was a puzzling question and a fruitful subject of debate by ancient philosophers. Aristotle taught that there were large cavities in the interior of the earth filled with air and that this air condensed to water on the cold ceilings and made its way to the surface through fissures. Vitruvius believed that springs were due to an accumulation of rain and melted snow in subterranean reservoirs. Descartes imagined that the sea was the source of the water which flowed into subterranean caverns, was vaporized, and afterwards condensed, finally escaping to the surface through crevices in the rocks.

The water of mineral springs, as of all other springs, is now, however, recognized as no new creation, but it is well known that the spring is only one of the phases of an aqueous circulation which begins and ends in the clouds that envelope our globe. Falling through our atmosphere as rain, after it reaches the earth the water ever seeks lower levels, and while a large part passes directly to the ocean through the lakes and streams, a very considerable portion sinks into the earth through the crevices in its rocks, and issuing later as a spring in some lower and more favorable level, eventually reaches the ocean, whence by evaporation it once more becomes a part of our cloudy envelope. In the latter part of the seventeenth century, Mariott, a French physicist, and Halley, the eminent English astronomer, independently of each other, the one by physical methods and the other from an astronomical point of view, demonstrated that the evaporation from the ocean is sufficient to account for the supply of water to all the springs and lakes and rivers that supply water to the sea. Buffon later demonstrated the same theory by selecting a lake without an outlet and proving that the evaporation from its surface was equal to all the water that was poured into it. It was anciently believed that all the rain water that fell upon the earth either ran off or was absorbed by the surface strata a short distance below the soil; but the constant dripping of water from the roofs of mines and tunnels proved this view to be incorrect. In Misnia, in Saxony, water forms in drops on the roofs of mines 1,600 feet below the surface, and when the railroad tunnel through Mount Cenis was cut into rock hard enough to turn the best steel, that rock was found to be so filled with water that a canal had to be built through the center of the tunnel to carry it away. Prof. T. Sterry Hunt estimates that a square mile of sandstone 100 feet in thickness will contain water sufficient to sustain a flow of a cubic

foot a minute for more than thirteen years. The water reaches the surface through springs in several ways. Sinking below the surface it penetrates the strata to a greater or less depth and is frequently subjected to an enormous hydrostatic pressure as it reaches lower levels; and when a favorable opportunity occurs through a crevice in the rocks, this pressure forces it to the surface, or boring for an artesian well gives it the necessary outlet. Many springs, however, find their way out naturally, as they flow from high altitudes to lower ones, and some waters, especially in the case of hot springs, are forced to the surface by an accumulation of steam, or exist as geysers from the very fact of their higher temperature. The accumulation of gas is also effective in the case of many cold springs, or in some springs that alternately throw out gas and water. The great majority of springs, however, reach the surface quietly either along the base of mountain ranges, or in valleys, or at the coast line. Their supply area is the higher mountain region that receives the water as rain. This, then, ordinarily sinks until an impervious stratum is reached, along which it flows until it emerges at the first favorable opportunity at the lower level, either as an ordinary spring, as a mineral spring if the rocks through which it passes are favorable, or as a hot or warm spring if it penetrates to a great depth or comes into contact with heated rocks before issuing at the surface of the earth.

FLOW OF MINERAL SPRINGS.

To those who have only casually considered the subject, the outflow from springs is somewhat surprising in amount. Le Coq says that of 500 springs in central France, 231 have been gauged and yield 2,628,000 gallons each every twenty-four hours. This, however, is small compared with the "Orange Spring," in Florida, which is said to pour out over 5,000,000 gallons per hour. During the eruptions of the Excelsior geyser, in the Yellowstone National Park, enough water is thrown out to double the volume of the Fire Hole river, upon whose bank it is situated. The river at this point is from 2 to 3 feet in depth and nearly 100 yards in width.

Very few observations have been made as to the permanence of flow of our springs, but mineral springs coming from considerable depths are not liable to the fluctuations seen in surface waters. The following is a list of our mineral springs that have a flow of 1,000 gallons or more per hour:

Name of spring and location.	Flow per hour.
	Gallons.
Addison Mineral Spring, Maine	1,800
Lake Auburn Mineral Spring, Maine	2,000
Summit Mineral Spring, Maine	2,280
Bradford Mineral Springs, New Hampshire	2,000
Brunswick White Sulphur Springs, Vermont	1,000
Allandale Springs, Massachusetts	1,250

Name of spring and location.	Flow per hour.
	Gallons.
Everett Crystal Spring, Massachusetts	3,000
Avon Sulphur Springs, New York	7,660
Iron Spring, Ballston, New York	4,000
Crystal Springs, New York	1 250
Chlorine Spring, Syracuse, New York	2,000
Excelsior Spring, Syracuse, New York	1,000
Dansville Springs, Syracuse, New York	1,000
Lebanon Thermal Spring, New York	30,000
Champion Spring, Saratoga, New York	2,500
High Rock Spring, Saratoga, New York	1,000
Pavilion Spring, Saratoga, New York	12,000
White Sulphur Spring, New York	2,400
Sharon Springs, New York	7,680
Slaterville Magnetic Spring, New York	2,700
Warm Spring, Perry county, Pennsylvania	5,400
Massanetta Mineral Springs, Virginia	30,000
Roanoke Red Sulphur Springs, Virginia	1,278
Warm Sulphur Springs, Bath, Virginia	360,000
Berkeley Springs, West Virginia	3,000
Blue Sulphur Springs, West Virginia	2,000
Greenbrier White Sulphur Springs, West Virginia	1,860
Sweet Springs, West Virginia	48,000
All Healing Springs, North Carolina	3,800
Alum Springs, Onslow county, North Carolina	90,000
Panacea Springs, North Carolina	3,700
Artesian Well, Citadel Green, Charleston, South Carolina	1,500
Chalybeate Springs, Merriwether county, Georgia	1,500
Magnolia Springs, Georgia	3,000
New Holland Springs, Georgia	1,200
Warm Springs, Merriwether county, Georgia	84,000
White Sulphur Springs, Merriwether county, Georgia	1,200
Blue Spring, Florida	73,920
Green Cove Spring, Florida	3,000
Orange Spring, Florida	5,055,000
Salt Springs, Marion county, Florida	148,000
White Sulphur Springs, Florida	1,200,000
Bladen Springs, Alabama	1,250
Healing Springs, Alabama	3,100
Belmont Springs, Mississippi	3,600
Castalian Springs, Mississippi	7,200
Castalian Springs, Tennessee	12,000
Jordan's Springs, Tennessee	6,000
Blue Lick Springs, Kentucky	12,200
Grayson Springs, Kentucky	2,800
Kuttawa Springs, Kentucky	1,200
Blanchard Springs, Arkansas	1,700
Blood Springs, Arkansas	2,000
Dove Park Springs, Arkansas	2,160
Eureka Springs, Arkansas	1,675
Floods' Chalybeate Spring, Arkansas	9,000
Hot Springs, Arkansas	20,100
Siloam Springs, Arkansas	12,800
Carrizo Springs, Texas	7,000
Dalby Springs, Texas	1,600
Pecan Springs, Texas	21,600
Sour Springs, of Caldwell, Texas	1,200
Electro-Magnetic Springs, Ohio	1,100
Green Mineral Spring, Ohio	375,000
Yellow Springs, Ohio	6,600
Cameron Springs, Indiana	1,100
French Lick Springs, Indiana	1,100
Kannal Spring, Indiana	1,800
Trinity Springs, Indiana	18,000
West Baden Spring, Indiana	1,500
Ganymede Spring, Illinois	3,000
Spring Valley Springs, Illinois	2,000
Prairie du Chien Artesian Well, Wisconsin	3,620
Bethesda Spring, Waukesha, Wisconsin	4,200
Glenn Spring, Waukesha, Wisconsin	45,000
Horeb Spring, Waukesha, Wisconsin	1,500
Mineral Rock Spring, Waukesha, Wisconsin	2,200
Siloam Spring, Waukesha, Wisconsin	1,000
Vesta Spring, Waukesha, Wisconsin	1,200
Iodo Magnesian Spring, Beloit, Wisconsin	10,000
Jacob's Artesian Well, Milwaukee, Wisconsin	18,000
Sheboygan Mineral Spring, Wisconsin	8,400
Sheridan Springs, Wisconsin	1,000
Chamberlin Mineral Springs, Iowa	2,000
Big Mineral Sorings, Iowa	6,400
Linwood Springs, Iowa	30,000
Blankenship Medical Springs, Missouri	2,000
Sweet Springs, Missouri	1,100
Akesion Springs, Missouri	4,000

Name of spring and location.	Flow per hour.
	Gallons.
Blue Lick Springs, Missouri	3, 000
Great Salt Springs, Missouri	10, 200
Boiling Spring, Benton county, Missouri	5, 000
Monegaw Springs, Missouri	18, 000
Union Springs, Kansas City, Missouri	1, 000
Clinton Artesian Wells, Missouri	3, 400
Guyer's Hot Springs, Idaho	2, 000
Hot Springs, near Boise City, Idaho	15, 400
Mound Springs, Boxelder county, Utah	1, 000
Salt Lake City Warm Springs, Utah	32, 903
Utah or Bear River Hot Springs, Utah	6, 500
Artesian Magnetic Mineral Spring, Pueblo, Colorado	5, 000
Hot Sulphur Springs, of Middle Park, Colorado	16, 980
Idaho Hot Springs, Colorado	2, 000
Poncho Hot Springs, Colorado	1, 000, 000
Salt Spring, Pueblo, Colorado	7, 000
Seltzer Mineral Springs, Colorado	1, 000
Ojo Caliente, New Mexico	6, 000
Hot Springs near Wellington, Nevada	91, 000
Hot Springs near Toyabe, Nevada	35, 000
Goodrich Spring, Nevada	28, 000
Shaw's Hot Springs, Carson, Nevada	4, 000
Smoky Valley Geysers, Nevada	4, 200
Whelan's White Sulphur Springs, Nevada	5, 000
El Paso de Robles Springs, California	11, 000
Geyser Springs, California	1, 000
Hot Borate Spring, Lakeport, California	18, 000
Harbin Mineral Springs, California	1, 500
Matilija Hot Springs, California	8, 000
Warner's Ranch Springs, California	1, 400
Coronado Mineral Springs, California	50, 000
Mark West Springs, California	5, 700
Napa Soda Springs, California	4, 000
Paraiso Hot Springs, California	2, 000
Santa Ysabel Springs, California	20, 000
Seigler's Springs, California	3, 000
Ukiah Vichy Springs, California	20, 000
Belknap Hot Springs, Oregon	1, 260
Denny Springs, Washington	1, 640

SOURCE OF MINERALIZATION.

What is the source from which are drawn the various gaseous and solid constituents of mineral waters? This is a question easily answered when the solvent power of water is remembered in connection with its penetration of the rocks that enter into the composition of the earth's surface. The disintegrating effect of fairly pure water upon rocks is well known, but when it is remembered how vastly it is enhanced by the presence of carbonic acid gas, acquired in the passage of water through the atmosphere and the soil, we need not look very far for the source of the constituents of mineral waters. They are derived from the decomposition of the rocks through which the waters pass in their downward course. Carbonic acid may accumulate in considerable quantities, and, besides favoring the solution of calcium, magnesium and iron, it may be held in solution in excess in the water. Sulphates may be reduced to sulphides and yield hydrogen sulphide. Organic matters also play an important part. In addition to chemical action, high temperature may assist in the breaking down of the rocks, and water under great pressure, without the aid of heat or with chemical action alone, may dissolve out not only the more soluble constituents of rocks,

but others not usually considered so, as silica, which is very sparingly soluble.

In passing through the sedimentary rocks many of the previously deposited salts are redissolved, and in these and in the constituents of the metamorphic and igneous rocks may be found all the solid constituents that we find in mineral waters. They may be rearranged in the mineral waters after solution by chemical action, but there is no difficulty in accounting for the presence of any of the elements that are found upon chemical analysis.

GEOLOGICAL POSITION.

Inasmuch as mineral waters derive their solid constituents from the rocks through which they pass on their way down and up before their emergence as springs, there must be an intimate connection between them and the geological structure of the country. A comparison of the geological map of the United State with a map of its mineral springs is very instructive in this respect. In regions where the older or metamorphic rocks constitute the surface formation, or are near to it, the waters as a rule contain a much smaller percentage of solid contents than in those regions where the water, to reach the surface, must come through sedimentary rocks which are not only more readily affected by the solvent powers of the water on account of their structure, but naturally contain a larger proportion of readily soluble salts. Again, it will be seen that thermal springs in the eastern United States are limited mainly to those regions where there has been more rugged mountain corrugation. The hot and warm springs of Virginia and the warm springs of North Carolina and Georgia are found within the limits of the Appalachians, and in Arkansas the hot springs are found in connection with the Ozark mountain uplift. When the eastern section of the country is compared with the western half, which includes the Rocky mountain region, the great preponderance of hot springs in the latter is at once apparent, and the contrast between the two sections in this respect is striking. It is true that in Florida most of the springs are slightly thermal, and that in the Mississippi valley there are a number of artesian wells whose water is also thermal, but in both cases this increased temperature is probably due to the greater depth from which the water comes. In the Rocky mountain region and other parts of the far west, in addition to the mountainous character of the country, which is also of recent origin compared with the Appalachians, we have a region of more recent volcanic disturbance and one in which rocks of igneous or eruptive origin cover extensive areas. It has long been a well known fact that the lines of junction between the sedimentary rocks and the older formations, especially along the bases of mountain ranges, are localities favorable for the occurrence of warm

and hot springs. Daubeny pointed out the connection of hot springs with fissures and lines of elevation, and Prof. James D. Forbes,[1] in 1835, confirmed Daubeny's views and pointed out the fact that the springs of the Pyrenees in almost every case were situated "just at the boundary of the granite with the stratified rocks."

These lines of junction are naturally weak points, and feel the stress of an uplift first, and they are therefore the points at which the greatest number of fractures and fissures occur and give the best egress to the water. When two or three axes of elevation cross each other the disturbance is greater, and as at Aix in France, and Leuk in Switzerland, and at Mont Blanc, it is not a matter of surprise to find thermal springs.

Prof. W. B. Rogers has pointed out the connection of the warm springs of Virginia with the faults and anticlinal axes of the Appalachian mountains. In almost every country the connection between thermal springs and mountain ranges is readily recognized, and just as apparent is the connection between hot and warm springs and the occurrence of volcanic rocks the world over. Mr. G. K. Gilbert some years ago called attention to the fact that the hydrothermal contrast between the eastern and western portions of the country is in accord with the geological conditions, and he referred the greater heat in the latter to local uprisings of the geiso-thermal planes, together with progressive corrugation, the intensity of the phenomena being heightened by the intrusion or extrusion of lava.

The western States may be divided into four great divisions, viz, the Rocky mountain region, the Plateau region, the Great Basin, and the Pacific coast. In the Rocky mountain region mountain corrugation is probably the primary cause of the hot springs, although in many places it is associated with the occurrence of igneous rocks, as, for instance, in the Yellowstone National Park, where the latter are undoubtedly the cause of the geyseric phenomena.

On the Pacific coast we find a similar association of the two causes, the uplifts of the Sierras and Coast ranges having been accompanied with volcanic outbursts, which in Alaska become a striking feature, the activity there being a thing of the present. All of the Alaskan mineral springs so far as known are either warm or hot.

In the Great Basin mountain corrugation is subordinate to the dislocation of strata due to profound faulting. Prof. I. C. Russell describes the region as follows: "The whole immense region lying between the Sierra Nevada and Rocky mountain systems has been broken by a multitude of fractures having an apparently north and south trend, that divide the region into long, narrow orographic blocks." With the faults thus described by Russell are associated hot springs, and a map of the hot springs of the Great Basin would be to a great extent a map of

[1]On the temperature and geological relations of certain hot springs, particularly those of the Pyrenees. Philosophical Transactions, 1836.

its displacements, just as a map of the hot springs of the world would be a very good map of the lines of volcanic disturbance of the globe. With the faults of the Great Basin volcanic rocks are also frequently associated.

In the plateau region a similar association of faulted strata and the former outpouring of lavas is noted.

Thermal springs are not the only mineral waters found in connection with faulted strata. The disturbance accompanying the formation of faults is the most efficient cause of cracks and fissures through which waters can find their way to the surface. The springs of Saratoga are a notable instance of the association of cold mineral springs with profound faulting. In this case, however, there is no connection with igneous rocks and the water which has its source primarily in the mountains to the eastward of Saratoga is probably tapped at a comparatively short distance from the surface, and hence has not acquired the temperature that other deeper springs get from the normal downward increase of temperature of the earth. This increase of temperature, as given by different authorities, ranges from 1° F. in every 23 feet descent to 1° F. in 68 feet. Recently Dr. Wm. Hallock of Columbia College, New York, as the result of observations on the deep well at Wheeling, W. Va., states that down to 3,200 feet the gradient is 1° F. for every 81·5 feet, whereas the last few hundred feet show an increase of 1° F. for about every 60 feet.

CLASSIFICATION.

That a classification of the various mineral waters is desirable is a proposition from which no one dissents, and many writers have presented schemes.

Systematic arrangement is necessary for a comprehensive view of the subject, no matter what the standpoint, and is naturally made in some shape or other by everyone. The universal use of water for drinking purposes led men at first to divide waters into potable and nonpotable (or drinkable and nondrinkable), but mineral waters were very early differentiated, and divided into classes according to their predominant characters or the qualities which appealed most strongly to the senses of taste and smell. In the time of Aristotle they were classified according to the vapors or gases they contained, and Pliny in the first century divided them into acidulous, sulphurous, saline, nitrous, aluminous, and bituminous. Many of our classifications of to-day have advanced but little beyond this early scheme. If they are in any sense chemical, they are generally based upon properties that are not analogous, terms denoting gaseous contents being made equivalent to those referring to the solid constituents. Usually, however,

there is a mixture of chemical and therapeutic classifications with other characteristics referable to physical sensations, which are all considered in these schemes as coordinate. Thus the terms alkaline, purgative, thermal, and sulphur waters, are found in most classifications as divisions of the scheme, each one of equal value so far as the classification goes.

Any classification must, from the nature of the case, be somewhat arbitrary, inasmuch as nature herself is an evolution, and we find that waters so shade into each other that it is difficult to draw hard and fast lines; but it is certainly not necessary to adopt a scheme based on such diverse properties as the contained gases, the therapeutic effect, the solid contents, and the sensation of heat, all jumbled together. The thermal waters may be alkaline, sulphureted, or purgative, and so purgative waters may be sulphureted and alkaline waters may be carbonated or sulphureted. A German classification divides the waters into I, alkaline; II, Glauber salt; III, iron; IV, common salt; V, Epsom salt; VI, sulphur; VII, earthy and calcareous; VIII, indifferent. Class IV is divided into 1, simple; 2, concentrated; 3, with bromine and iodine. This subdivision corresponds to the proportion of sodium chloride contained in the water, and with Class VII can be just as well expressed by arranging the waters according to the amount of salt contained, beginning with the weakest or with the strongest.

A classification, as already indicated, may be either geographic, geologic, therapeutic, or chemical. The first two, however, in view of the uses to which mineral waters are put, are of little practical value. A therapeutic classification would be most desirable, but the conditions at present, in this country especially, are such as to render it impossible. A chemical classification naturally precedes one based upon the application of the waters to the treatment of disease, even if we were not reduced by the necessities of the case to a scheme based mainly upon the predominance of one or more of the ingredients of the water. Minor constituents must be ignored to a certain extent, but the chemical composition can be relied upon with a reasonable degree of certainty for the therapeutic indications, as certain well defined effects, resulting from the probable combinations of the elements found, may be looked for. It is the more reliable from the fact that we have the results of the experience of those who have made a study of the well known European mineral waters and can compare our analyses with theirs, confidently expecting the same results from similar waters.

The scheme of classification briefly outlined below[1] is applicable not only to our own mineral waters, but to all, no matter from what part of the world they may come. Any truly scientific scheme ought to be broad enough to include any mineral water that may hereafter be analyzed.

[1]This scheme is described by the writer in detail in the Transactions of the American Climatological Association, May, 1887, pp. 156–166.

The following is the

SCHEME OF CLASSIFICATION.

GROUP A. NONTHERMAL.

GROUP B. THERMAL.

- Class I, Alkaline.
- Class II, Alkaline-saline
  1. Sulphated.
  2. Muriated.
- Class III, Saline
  1. Sulphated.
  2. Muriated.
- Class IV, Acid
  1. Sulphated.
  2. Muriated.
  3. Siliceous
     - Sulphated.
     - Muriated.

Any spring belonging to one of the above classes in any of its subdivisions may be characterized by the absence of all gases (that is, may be nongaseous) or, by the presence of carbonic acid gas, sulphureted hydrogen, etc., when it is designated by one of the following terms, viz:

1. Nongaseous (free from gases).
2. Carbonated (containing carbonic acid gas).
3. Sulphureted (containing hydrogen sulphide).
4. Azotized (having nitrogen gas).
5. Carbureted (having carbureted hydrogen).

There may be a combination of gases, which is indicated by the combination of the terms, as sulphocarbonated, etc.

The classes may be further subdivided according to the predominant solid constituent as follows:

1. Sodic. 2. Lithic. 3. Potassic. 4. Calcic.
5. Magnesic. 6. Chalybeate. 7. Aluminous.

Here also there may be a combination which can be indicated by a combination of the terms, as calcic-magnesic, etc.

A few words of explanation may be necessary as to the classes outlined above.

The alkaline waters (Class I) include all those which are characterized by the presence of the alkaline carbonates, as the carbonates of the alkalis, the alkaline earths, alkaline metals, and even of iron alone, although the latter is usually associated with other carbonates. Generally these waters are characterized by the presence of free carbonic acid—the acidulous springs of some classifications—and would therefore be additionally designated as carbonated. There are carbonated acid sulphated springs (i. e., springs with free carbonic acid, free sulphuric acid, and sulphates) and to call them acidulous acid springs would be awkward to say the least. Nearly one half of the alkaline springs of the United States are calcic-alkaline—that is, with calcium carbonate or bicarbonate as the predominant ingredient.

The saline waters (Class III) include those in which sulphates or chlorides predominate. They are probably one-third more numerous in the United States than are alkaline waters. Almost all of the springs usually classified as purgative or aperient saline would fall under the head of sulphated salines. Thus a sodic-sulphated water and a magnesic sulphated water could hardly be mistaken for anything else than purgative waters. Under the head of muriated salines all the brines would fall, as they are characterized by the presence of sodium chloride. Any of the salines may be sodic-sulphated, or sodic-muriated, or calcic-sulphated, calcic-muriated, etc. The sodic-muriated springs constitute 88 per cent of the muriated saline waters of the United States.

The alkaline-saline waters (Class II) include all in which there is a combination of alkaline carbonates with the sulphates or chlorides, and they are divided just as the saline waters are, and may be still further subdivided in the same way into calcic, chalybeate, magnesic, etc., and are characterized still further, as are the other classes, by the absence or presence of gases. They are about one-third as numerous in the United States as the saline waters.

The acid class (IV) takes in all the waters that contain free acid, whether it be silicic acid, sulphuric acid, or hydrochloric acid. The sulphated acid springs contain free sulphuric acid and also sulphates of various salts. The muriated acid springs have free hydrochloric acid as their predominant constituent, with various chlorides; and the siliceous acid springs are characterized by the presence of silicic acid in great quantity, and are still further divided into sulphated and muriated, according to the presence of the sulphates or of the chlorides in addition to the silicic acid.

To illustrate the applicability of the scheme three cases will suffice.

The High Rock spring and most of the other springs at Saratoga would be described as carbonated sodic-muriated alkaline-saline springs, i. e., the water contains free carbonic acid gas, its predominant solid constituent is sodium chloride, but it also contains alkaline carbonates. It belongs to Group A, as no temperature is given, it being a cold spring.

The water of the Gilroy hot springs of California would be described as a hot sulpho-carbonated sodic-muriated saline water, i. e., it contains both free carbonic acid gas and sulphureted hydrogen, and its principal solid constituent is sodium chloride. It belongs to Group B, as it is a hot water.

A third example is the Hot Springs of Virginia. The water of the Boiler springs, one of its many springs, may be described as a hot carbonated calcic-alkaline water, i. e., it contains free carbonic acid gas, the principal solid ingredient is calcium carbonate, and it belongs to Group B (thermal waters).

The designation of a mineral water according to this scheme enables any one, be he physician or layman, at once to get a definite idea of its

general chemical composition and to obtain a clew to its probable therapeutic effect, and qualifies him to pick it out as a water probably suitable for certain cases, after which a more careful study of its analyses will enable him to determine whether or not it meets all the requirements for the individual and particular case.

THERMAL SPRINGS.

A few words may be added upon the subject of thermal springs, as we have divided mineral springs into two groups according to their temperature. Strictly considered, all springs whose mean annual temperature (no matter in how small a degree) is above that of the mean annual temperature of their localities is a thermal spring. There is a variation, therefore, according to their geographical position. Thus, springs in Alaska or Siberia, where the ground is constantly frozen to the depth of several hundred feet, which have a temperature between 32° and 42° F. and never freeze, are warm springs, while the same springs in the East or West Indies or under the equator would be cold springs. For practical purposes we must draw an arbitrary line, and it has been found most convenient to consider all springs with temperatures above 70° F. as thermal springs; those whose waters have temperatures between 70° and 98° F. are called tepid or warm; and all over the latter temperature are designated as hot. All the thermal waters (Group B of the classification) are subdivided, as are all the nonthermal waters (Group A). They may be carbonated, sulphureted, etc., or alkaline, saline, alkaline-saline, etc. It has generally been supposed that they are less highly mineralized than nonthermal waters. A priori, hot water is a better solvent than cold water, and if sometimes a thermal water is less highly mineralized, it is probably because it comes from a greater depth, where the rocks are of such a character as to be less readily acted upon. Other things being equal, there is no reason why a thermal water should not contain the same ingredients that a nonthermal water has. The fact that a spring is thermal is dependent largely upon its geological position, as already indicated. The rocks in which they originate are usually not so readily disintegrated, as are the more soluble sedimentaries. Where the two groups of springs occur in the same geological position we find little, if any, difference in regard to the quantity of solid contents that is to be seen. At the Hot Springs of Virginia one of the springs, with a temperature of 78° F., has 18·09 grains per gallon of solid contents, while another, with a temperature of 110° F., has 33·36 grains per gallon. At the Bath Alum springs, in the same region, with a temperature of 60° F., the total solid contents are found to be 45·44 grains per gallon (Spring No. 1), which does not differ materially from the results noted at the Hot Springs. At the California geysers the coldest spring, with a temperature of 70° F., has 7·12 grains per gallon, while the hottest, at 212° F., contains 296·4 grains per gallon.

As stated under the head of "geological position" (pages 62–64), the cause of the heat of thermal springs is to be found in their proximity to, or their source in rocks of volcanic or igneous origin; in their occurrence in areas of mountain corrugation or of profound dislocations; or, if they come from great depths, in the normal downward increase of the temperature of the globe. Chemical action as a source of heat plays little, if any, part as a cause. The downward increase of heat is not the same at all places, and one can not tell, with any certainty, the depth of the spring from its temperature. The question of the permanency of the heat is an interesting one. Usually it is very persistent, especially where it is due to the temperature of the earth itself. In regions where there are active volcanic manifestations and earthquakes, fluctuations of temperature in springs have been very common. Prof. Forbes, in his study of the hot springs of the Pyrenees in 1835, compared his observations with those taken nearly one hundred years previously, and in many cases found a remarkable uniformity in the temperatures taken at different times throughout the period. In the case of our own springs, the data are insufficient for the making of careful comparisons in respect to changes of temperature. In one case, however, viz, the hot springs of Salt Lake City, a considerable variation in temperature has been noted. Ordinarily these springs have a temperature of 122° F., but in 1889, for one month, June to July, and at irregular intervals in preceding years, the springs became as cold as 50° F.

A comparison of the temperatures of the hot springs of Virginia, North Carolina, and Arkansas, taken recently, with those taken years ago, shows little change, most of the differences noted being due probably to variation in the thermometers, so that the comparative observations have little value.

CHEMICAL COMPOSITION AND ANALYSES.

The fact that we are narrowed down to the chemical composition of mineral waters as a basis for their classification makes it very important that the analyses, if not made by the same chemist in all cases, should be made upon some one definite method and be stated with some degree of uniformity. As a matter of fact, the analyses of mineral waters have been made upon almost as many plans as there have been chemists making the analyses. An inspection of about a thousand analyses of mineral waters of the United States shows that at least forty-two methods of stating the results have been employed. They range from parts per hundred to parts per million; from grains per cubic inch to grains per pint; and from grains per pint of various kinds through grains per quart to grains per gallon. Two or three scales were frequently found in the same table. Some gave only the elements actually found, and others only the probable combi-

nations. Under such circumstances, a comparison of the different analyses is obviously impossible.

Bergman, the Swedish chemist, was the first to outline a systematic scheme of water analyses in a paper published about 1788. He began with the examination of the physical qualities, and distinguished the matters held in solution from those mechanically suspended. He also succeeded in manufacturing artificial mineral waters by combining elements similar to those found in well known mineral springs. Dr. John Murray, in 1816, still further systematized the plan for water analyses, and published a general formula for the analysis of mineral waters. He took the ground that the salts existing in the water need not be exactly the same as those obtained upon its evaporation, recognizing the fact that salts deemed incompatible may coexist in a state of weak solution, and though he combined the acids and bases determined, according to their solubility, into what he supposed was their most probable combination in the water, he held that the analysis consisted in the determination of the several acids and bases. Berzelius contended that, everything beyond the mere statement of the acids and bases being matters of hypothesis, nothing should be set down but their respective weights. This alone, however, is not sufficient, for while it might satisfy the chemist or the geologist, it would not be enough for those who are mainly concerned in the use of the water, viz, medical men. They wish the analyses to be so stated that the probable effect upon the human system may be determined, and therefore it is necessary for a clear comprehension of these points that the probable composition be also given. If at the same time the elements actually found are also given there can be no cause for complaint from anyone. It is, of course, impossible to ascertain the exact arrangement of the elements found upon analysis. In a solution of sodium chloride and potassium sulphate, both sodium sulphate and potassium chloride will be found in addition to the two original salts; and when in addition other substances by their presence render the conditions more complex, the impossibility of determining the exact arrangements of the elements in the water is very apparent. Other things being equal, however, it is probable that the strongest acid will always unite with the strongest base, and to obtain an idea of the medicinal value of the water, even if only approximate, it is desirable to state the probable combination. From these statements it can readily be seen how vastly more valuable the results of our mineral water analyses would be if this combining of the elements into their probable combinations were in all cases made upon a uniform plan.

Although nearly all of the modern works upon chemistry and chemical analysis present schemes of water analysis and give usually very complete instructions, very little is said as to the method of stating the results. Henry Noad, in his Manual of Chemical Analysis, advises that the electro-negative and electro-positive ingredients be arranged

as established by direct experiment into binary combinations in the ratio of their mutual affinities, the strongest acid being combined with the strongest base, attention being paid to the fact that the force of affinity is considerably modified by the degree of solubility of the salts. He also says that the direct results should be given, and the total amount of the final constituents must agree with the joint amounts of the several ingredients. Such examples as he gives are expressed in grains to the imperial gallon. Nearly all of the forms in which analyses are expressed can be reduced to one or another of the following methods of expression:

(1) In grains per English or imperial gallon (277 cubic inches or 10 pounds, 70,000 grains of pure water).

(2) In grains to the United States or wine gallon (231 cubic inches, 58,372 grains of pure water).

(3) On a decimal basis as parts per 100, 1,000, 1,000,000, etc. This is usually the form adopted in Germany and France, also in the reports of the Rivers Pollution Committee of Great Britain, and in the United States by the National Board of Health, and by many State boards of health.

(4) As so many milligrams to the liter, which would be the same as parts per 1,000,000 if the liter always weighed exactly 1,000 grams.

The variation of the specific gravity in the case of ordinary potable waters would be of little account, but in the case of most mineral waters, especially of those that are highly mineralized, the difference between parts per million and milligram per liter is too great to be disregarded, and precludes in the same analysis the use or combination of measure by weight and measure by volume if the analyses are to be exact and mutually comparable. The following recommendations were made by a committee of the Chemical Society of Washington in February, 1886.

(1) That water analyses be uniformly reported in parts per million or milligrams per kilogram, with the temperature stated, and that Clark's scale and all other systems be abandoned.

(2) That all analyses should be stated in terms of the radicals found, whether elementary or compound.

(3) The constituent radicals should be arranged in electro-chemical series, the positive radicals first.

(4) The combinations deemed most probable by the chemist making the analyses should be stated both by symbol and by name.

By "terms of the radical found" is to be understood the immediate results of the actual analysis, so that any one examining the analytical results will have the same facts as the chemist making the analysis. Thus, if ammonia is found it should be stated as ammonia (NH_4), if nitrogen (N) alone it should be so stated. The use of symbols was

[1] Bulletin No. 2 of the Chemical Society of Washington, 1887, p. 44. Report of committee (A. C. Peale, W. H. Seaman, C. H. White) on method of stating water analyses.

recommended to do away with any obscurity as to the compounds, as, for instance, in the case of the salts of iron.

It is generally supposed that the statement "grains per gallon" presents to nonprofessional people a more definite idea than parts per million. Yet investigation will show that outside of chemists and pharmacists the idea as to what a grain of any particular substance means is very vague. A gallon of water also varies according to temperature, and besides, grains per gallon are incommensurable quantities, whereas parts per million, per hundred, or per thousand can be readily understood by anyone.

It is frequently desirable to convert an analysis from one form to another, and a few words on this subject may not be out of place here.

As the weight of the same volume of water differs according to its density and its temperature, the value of a gallon, even if it is a wine gallon, is somewhat indefinite unless these factors are stated. The following table compiled from Oldberg will show how this varies:

Apparent weight of water at different temperatures.[1]

	Temperature of air = 62° F.; temperature of water = 39·2° F.; 1 cubic inch = 252·761 grains.		Temperature of air = 62° F.; temperature of water = 59° F.; 1 cubic inch = 252·554 grains.		Temperature of air = 62° F.; temperature of water = 62° F.; 1 cubic inch = 252·48843 grains.		Temperature of air = 71·6° F.; temperature of water = 71·6° F.	
	Grams.	*Grains.*	*Grams.*	*Grains.*	*Grams.*	*Grains.*	*Grams.*	*Grains.*
One liter	999·512	15,424·831	998·695	15,412·215	998·435	15,408·204	997·5	15,393
One United States or wine gallon	3,783·466	58,387·855	3,780·371	58,340·011	3,779·387	58,321·827	3,776	58,270
One imperial or English gallon	4,540·820	70,075·500	4,537·199	70,018·111	4,535·926	70,000	4,532	69,934

[1] From Oldberg's Manual of Weights, Measures, and Specific Gravity, etc., Chicago, 1885, pp. 167–171.

Oldberg recommends the temperature of 71·6° F. as the best for all practical purposes in pharmacy, as it is probably the most common room temperature.

According to the Century Dictionary the United States gallon contains 231 cubic inches, and is equal to a cylinder 7 inches in diameter and 6 inches high, and is taken at the value of 8·3389 pounds avoirdupois of water at its greatest density weighed in air at a pressure of the barometer of 30 inches, and a temperature of 62° F. It is equal to 3·7853 liters. Prof. Paul Schweitzer of the Missouri state geological survey, using this statement in connection with the values published by the Office of Standard Weights and Measures (T. C. Mendenhall, superintendent, Washington, D. C., 1890), makes the following statement: "In view of the differences in the weight of the same volume of water, each one of which seems to rest upon an equally secure basis, and in further view of the fact that the liter flask, as made and sold by dealers in chemical apparatus, is intended to discharge 1 kilogram of water at 15·5° C., the value commonly employed in such calculations,

viz, 3·785 liters to the gallon and 15·432 grains to the gram, are employed; they make 1 gram per liter equal to 58·410120 grains per gallon, the value adopted."

He gives the following table for the reduction of grams ~~grains~~ in the liter to grains United States gallon:

Grams ~~Grains~~ per liter.	Grains per United States gallon.
1	58·41
2	116·82
3	175·23
4	233·64
5	292·05
6	350·46
7	408·87
8	467·28
9	525·69

The following conversion table is given by Leffmann & Beam in their book on the examination of water for sanitary and technical purposes, Philadelphia, 1889:

Parts per 100,000 ×0·7=grains per imperial gallon.
Parts per 1,000,000 ×0·07=grains per imperial gallon.
Parts per 10,000 ×0·583=grains per United States gallon.
Parts per 1,000,000 ×0·058=grains per United States gallon.
Parts per 1,000,000 ×0·00833=number of pounds per 1,000 United States gallons.
Grain per imperial gallon, 0·7=parts per 100,000.
Grain per imperial gallon, 0·07=parts per 1,000,000.
Grains per United States gallon, 0·583=parts per 100,000.
Grains per United States gallon, 0·058=parts per 1,000,000.

GEOGRAPHICAL DISTRIBUTION.

The geographical distribution of the mineral springs of the United States (see Pls. III and IV) is of course connected with the consideration of their geological position, and as already indicated, a map of the thermal or hot springs shows that they are most numerous in the western part of the country. A map upon which all the mineral springs were indicated would show that no state or territory in the Union is without some spring that is utilized either for commercial purposes or as a place of summer resort or a sanitarium. A map (see Pl. IV) upon which only the springs whose waters are used commercially are platted at once shows that the majority of such springs are found in the eastern United States and in the Mississippi valley. West of the one hundred and first meridian they are largely confined to the Pacific coast. In Idaho, Colorado, New Mexico, and Montana we find altogether barely a dozen springs so used. This is not because the total number of springs in the east is so much greater than in the west, but is mainly because the former is the seat of the greatest population and consequently it is more thoroughly developed as to the utilization of its resources in the matter of mineral waters. A map of the mineral spring resorts

(see Pl. III) presents a much larger total number of springs and a more equitable distribution over the country, for many of our most improved and best known resorts are now found in the middle west, and in the Rocky mountain region. They in no respect suffer in comparison with those in the east or with those on the Pacific coast.

There are in some sections of the country waters commonly used for drinking purposes which if located elsewhere might be considered mineral waters. This is because all of the waters of those sections are mineralized, as in certain alkali regions of the west, and the people gradually become habituated to their use.

So far as the general geological features of the North Atlantic States are concerned they might be divided into the sections so long recognized in our older school geographies, viz, the New England and the Middle States. In the former the older rocks form a large part of the surface, which accounts for the fact that, as a rule, the mineral springs of that section are somewhat less highly mineralized than are those of the Middle States. No thermal springs occur in the section. The springs of Maine are slightly alkaline-saline and chalybeate. A few are carbonated and some are sulphureted. They range in temperature from 40° to 46° F. The solid contents range usually from 3 to 31 grains per gallon, the Lubec Saline spring being the only exception, the solid contents of its water reaching the total of 322 grains. In New Hampshire, chalybeate waters are the most common, and in respect to their total amount of solids they range from 2 to 15 grains per gallon. In Vermont also the conditions are much the same, except that sulphureted springs are more numerous. Massachusetts is not remarkable for its mineral springs. Chalybeate waters are common throughout the State, occurring in nearly every town. A mineral spring near Williamstown, in the northwest portion of the State, is said to be very slightly thermal, but it is hardly a warm spring. Very much the same statements may be made for Connecticut and Rhode Island as for Massachusetts. Many of the mineral springs of the New England States are utilized both for commercial purposes and for places of resort. In the Middle States we find a much larger number of mineral waters that are utilized, and the total number of springs is also greater. New York stands at the head of the section in regard to the total number of springs, and has more commercially used waters than any other State in the Union. There is also a very large production of salt from the salt springs of New York, in what are known as the Onondaga and Warsaw districts. New York has also one of the most celebrated acid springs in the country in the Oak Orchard spring, which contains free sulphuric acid. The Lebanon Thermal spring, with a temperature of 75° F., is the one spring of the group in this State, and Pennsylvania possesses, in the Perry County Warm spring, a very slightly thermal spring which has a temperature of 66° to 70° F. Bedford Springs is one of the oldest resorts in the latter State. Chalybeate springs outnumber all others

in Pennsylvania, New York, and New Jersey. In the latter, the Schooley mountain spring is the best known resort.

In their general geologic features the South Atlantic States are not unlike the Middle States, and naturally the springs are of the same general character. Thermal springs are, however, more numerous. Delaware has never had but one spring resort—the Brandywine Chalybeate spring—and this is now practically abandoned. Maryland has a fair number of resorts and several well known commercial waters; but Virginia is par excellence a mineral spring State, occupying among South Atlantic States the same position that New York does in the North Atlantic section, being second only to that State in the number of springs that are utilized commercially, and exceeding it in the number of resorts. The Hot Springs of Virginia are among the most celebrated in the country. The literature relating to the mineral springs of Virginia is very extensive. West Virginia is equally noted for its springs, having two of the oldest resorts in the United States in Berkeley springs, at Bath, and the Greenbrier White Sulphur springs. The general character of the springs in Virginia and West Virginia is the same, saline sulphureted waters being most numerous, although alkaline, chalybeate, and acid springs are found, both hot and cold. North Carolina also enjoys the distinction of possessing hot springs. In most respects the springs are not unlike those of the Virginias. Georgia, in the Warm Springs of Meriwether county, has an important thermal spring, and the State ranks with North Carolina and Virginia as a mineral spring State. Florida is remarkable, as already noted, for the great size of its springs, the flow from some of them being sufficient to float steamboats of considerable size. These springs are generally deep seated in their origin and are all slightly thermal and mostly sulphureted.

In the Southern Central States the saline springs outnumber all others, and the thermal springs are relatively few. A large part of the area is occupied by comparatively recent formations. Yet in the northern and western portions of the section, Carboniferous rocks with the underlying formations are well developed, and they are usually prolific of mineral spings. Tennessee, Kentucky, Arkansas, and Texas are the important mineral spring States of the section. The Hot Springs of Arkansas occupy a first place among the thermal waters, not only of that State but of the entire country. The springs of Kentucky and Tennessee have had considerable attention paid to them by geologists and chemists, and they have many well known resorts. Texas is noted for its springs, among which are a number of acid springs containing free sulphuric acid. In the western part of the State there are also many hot springs. In Alabama, Mississippi, Louisiana, and Indian territory there are a great many mineral springs, but they apparently have had little attention paid to them and we find that fewer of them have been improved than in the other States of the section.

The broad areas of Carboniferous rocks with underlying Devonian and Silurian strata that enter so largely into the surface formation of the Northern Central States, especially in the more southern portions, would lead us to expect in this section a development of mineral springs similar in general character to those of the Southern Central States, and this we find to be the case. Calcic springs are naturally numerous, while thermal springs are inconspicuous, most waters of this group being derived from artesian borings. In Ohio, calcic waters are especially abundant. In the belt of black Devonian shale that traverses the State from the Ohio valley to Lake Erie, nearly all the springs issuing from the base of the formation carry iron and are sulphureted. Out of the hundreds of springs that actually exist, only a few are utilized for medicinal purposes. In other parts of the State the waters come from the drift and underlying beds of bog iron ore, and they are therefore strongly chalybeate. The brine springs of Ohio have not been included in the list of mineral waters, as they are the source of one of the most important industries of the State, and have been considered from an economic standpoint elsewhere very fully. The Pomeroy or Ohio valley district is the most important in this respect, its salt wells being the most prominent in the State. The brines carry a small amount of sulphates and considerable iron, and, like all the Ohio brines, are rich in bromides.

The conditions in Indiana are similar to those of Ohio, and consequently the springs are much the same. Sulphureted and chalybeate springs predominate. The brines of Indiana are not so numerous as those of Ohio, and the production of salt is of comparatively little account. A fair number of the springs are utilized commercially, and in the total number of springs and the number of resorts the State ranks next to Missouri, which is first on the list for this section.

Illinois differs little from neighboring States, the same classes of springs being found within its borders that are seen in Indiana and Missouri.

Missouri is a State rich in mineral springs, and they are of great value in its economic resources. Nearly every county possesses mineral springs of wide local reputation, and many are well known beyond the State limits. The production of salt from salt wells was at one time a considerable industry. The Sweet Springs, of Saline county, are perhaps the best known, but there are many other well known health resorts, and the State holds average rank as a producer of commercial mineral waters. The springs are mainly saline and chalybeate, and many are slightly sulphureted.

Kansas derives a considerable portion of its mineral waters from ordinary wells and artesian borings. The waters are mostly saline, and are generally sulphureted. Chalybeate waters are abundant in certain sections of the State. In the eastern part sulphates of lime and magnesia are found in the hard waters of shallow wells, and as deeper

strata are penetrated, the sulphates decrease in amount and the chlorides increase. Nebraska is slightly developed so far as its mineral springs are concerned. Its known mineral waters, however, do not differ materially from those of Kansas.

Returning to the eastern part of the section, we find that Michigan derives its mineral waters largely from artesian wells, which are locally called mineral springs. These borings are mainly in the Corniferous limestone and the Huron group of the Devonian. The waters are well mineralized, and are popularly supposed to be magnetic. Sulphureted saline waters predominate. The brines of the State are very important, the salt industry dependent upon the salt wells being of large proportions.

In the northern part of the northern central section, where there are very considerable areas of metamorphic rocks, the springs are somewhat like those of the New England States in general character, especially in not being so highly mineralized as those of the States lying to the south of them.

The mineral springs of Wisconsin are particularly valuable, and the springs of Waukesha have a wide reputation. In the production of mineral waters for commercial purposes the State outranks all the others, as it does also in the value of the production. In the number of springs so used it is third upon the list. The springs are mainly calcic, alkaline, and chalybeate.

Minnesota and Iowa contain numerous springs whose waters are much like those of Wisconsin in respect to the comparatively small quantity of contained solids, and in their general character. The occurrence in Iowa of acid springs is interesting. So far as known, Minnesota has few mineral spring resorts. Iowa has several resorts and a number of its waters are bottled for sale.

In the Dakotas the recent development of these new States has resulted in little attention being paid to their mineral spring resources. In South Dakota many wells are known to be highly mineralized, and near the Black Hills we have in the Dakota hot springs the one thermal spring locality of the section.

In a general survey of the Western States the first thing to attract attention is the inequality in the development of the mineral spring resources. Another noticeable point is the far greater prevalence of thermal springs. Very naturally we find that California has made the greatest advance in mineral spring development. This is due to the fact that it has been longer settled, and has more time to devote to the mineral springs of which it has so large a number. Other States are beginning to appreciate the importance of a careful study of their mineral springs, and we find more and more attention being paid to them from year to year. The Western States (i. e., those west of the one hundred and first meridian) include a little more than 39 per cent of the total area of the country, and yet we find that they contain more than 80 per cent of

its known thermal springs. This great preponderance is likely to be increased in the future. It cause has been stated and described under the head of thermal springs. When we consider the number of individual springs contained within the limits of the Western States, the contrast with the Eastern sections is even more striking; not only is the number greatly in excess in the former, but the thermal phenomena are overwhelmingly greater in intensity. The Yellowstone National Park is the seat of thermal manifestations not equaled in any other part of the country, and in fact not excelled in any part of the world.

The proportion of improved springs in the Western States is, however, necessarily less than in other sections on account of the comparatively recent settlement of most of the country in and beyond the Rocky mountains.

California, as we have said, stands at the head of this section so far as the improvement of the springs is concerned, both in respect to the number of resorts and of its commercially used waters. Its mineral waters are of all classes and they are not confined to any one section of the state, but are found from one end to the other. With the exception of Wyoming, which includes the Yellowstone National Park, California contains a greater number of mineral springs than does any other State.

Of the Pacific coast States Oregon comes next to California in the number of its mineral spring resorts. The waters of several of these are bottled and sold.

The State of Washington, in its Medical lake, presents one of the best known mineral waters of the West. This water is condensed and bottled, and the evaporated salts, put up in packages, are extensively sold. Nevada is probably better off in respect to springs than in regard to streams of running water. Hot and cold mineral springs are found in every county, the former outnumbering the latter. Steamboat spring is probably the best known locality. Salt springs, soda springs and lakes, and borax lakes abound, and the ordinary potable waters in many parts of the State are strongly alkaline. In Arizona and New Mexico alkaline and saline waters, many of them carbonated and sulphureted, are so numerous that they attract but little attention. Frequently they are more common than pure waters. Many of the springs are thermal, and many were utilized by the Franciscan and Dominican friars when they first traversed the country, and also by the Indians long prior to the advent of Europeans. Saline springs are most abundant in Arizona, while both alkaline and saline springs are numerous in New Mexico. Several springs in New Mexico are utilized for commercial purposes, and Las Vegas Springs is one of the finest mineral spring resorts in the country.

Colorado, sometimes called the Switzerland of America, has had considerable attention devoted to its springs, and there are now within the limits of the State many well known resorts, of which perhaps Manitou, near Colorado Springs, is most widely known. A number

of waters are also used commercially. Hot and cold springs are both found; many are alkaline, others chalybeate, and saline springs are numerous. They are sulphureted and carbonated in many cases.

In Utah the presence of mineral springs, both hot and cold, was noted by all the early explorers and travelers who were obliged to cross the territory on their way to the Pacific. The hot springs near Ogden and those at Salt Lake City are the best known and most used. They are thermal, as are most of the mineral springs of the territory. Salt lake itself is one of the most highly mineralized bodies of water in the world.

The mineral springs of Idaho have secured very little attention, but it is well known that warm and hot springs are of frequent occurrence, especially in the granitic and igneous rocks of the mountainous portions of the State. "Hailey's hot springs" and the "Soda springs" of Bear river are the best known localities. The latter were first described by Fremont, who called them the Beer springs, and from one of the cold springs of this now well known resort is drawn the Idanha mineral water, which is extensively sold throughout the west.

Wyoming, with the immense number of springs in the Yellowstone National Park, easily stands at the head of the list for the entire country when we consider the total number of springs, as there are more than two thousand individual springs within the limits of the Park alone. The Yellowstone Park is, of course, the greatest spring resort in the country, and it is deservedly so, not only from the presence of its geysers but also on account of the great variety in its springs, which will one day undoubtedly be more highly prized for their medicinal virtues than they are now.

The proximity of Montana to the National Park is the principal reason why its numerous and important mineral springs have not received the attention and development that they undoubtedly deserve. Many of them have been known since the days of Lewis and Clarke's famous expedition across the mountains of Montana from the head of the Missouri river to the Pacific. Most of the springs in the State are thermal, and a number of them have been improved and are used to a considerable extent as resorts. The White Sulphur springs, Hunter's hot springs and Ferris's hot springs are well known locally, while the Broadwater hot springs near Helena are scarcely excelled anywhere, especially in respect to their improvements. The plunge bath there connected with one of the hotels, is one of the largest in the world. The springs of Montana present a great variety in their composition, and the water of one of the cold springs in the valley of the Yellowstone is almost identical with the celebrated Apollinaris water from Prussia.

Last of all, in Alaska we have a hot spring territory that has few equals. Little is known as to the mineral contents of the springs, but their number is very large and they are often found in contact with glaciers. So far as a cursory examination goes the springs are mainly

saline and most of them are sulphureted. There are many cold springs that never freeze and that are therefore in a strict sense thermal. The geysers or warm springs near Sitka, having a temperature of 153½° F., were used as the site of a hospital by the Russian authorities before our purchase of the country. Many of the hot springs have been used by the Aleuts from time immemorial for cooking purposes, while others are used as bathing places. Our knowledge of the Alaskan springs is due to scattered notes of travelers and explorers who usually have not the means of making careful scientific examinations, and we have no analysis of any of the waters.

The following table gives the rank of the States according to commercial statistics of 1892.

Rank of States according to commercial statistics.

	Rank according to springs used commercially.	Rank according to number of gallons produced.	Rank according to value of production.		Rank according to springs used commercially.	Rank according to number of gallons produced.	Rank according to value of production.
Alabama	12	36	23	Montana	15	35	28
Arkansas	11	32	31	Nebraska	15	38	39
California	4	15	10	New Hampshire	13	7	3
Colorado	8	11	9	New Jersey	15	37	38
Connecticut	11	34	24	New Mexico	12	29	34
Georgia	13	23	18	New York	1	2	2
Idaho	15	19	14	North Carolina	6	17	15
Illinois	8	18	20	Ohio	7	6	6
Indiana	7	22	33	Pennsylvania	6	5	4
Iowa	11	25	26	Rhode Island	14	16	32
Kansas	9	3	8	South Carolina	13	30	35
Kentucky	11	31	36	South Dakota	15	26	30
Louisiana	15	39	37	Tennessee	10	21	22
Maine	10	9	13	Texas	5	14	21
Maryland	11	27	25	Vermont	12	24	19
Massachusetts	8	8	12	Virginia	2	10	7
Michigan	8	4	5	Washington	13	20	11
Minnesota	15	12	27	West Virginia	10	33	29
Mississippi	12	13	17	Wisconsin	3	1	1
Missouri	7	28	16				

THE UTILIZATION OF MINERAL WATERS.

The principal use to which mineral waters are put is of course their application in the treatment of disease, and in this respect the mineral waters of the United States are no exception. The mineral spring circulars issued for the purposes of advertisement abundantly prove the statement. In many States salt springs are used as the source of common salt and thus add largely to the economic resources of their localities. Mineral waters are also utilized for the manufacture of borax, bromine, and carbonate of magnesia, and the waters of certain Western lakes are the sources of large quantities of soda. The mere mention of these facts is sufficient in this place. Returning to their primary use, that is, as remedial agents, the waters are utilized, first, at the springs both for drinking and bathing purposes and, secondly, they are bottled or other-

wise put up for sale and thus rendered available in the market at a distance from their source.

The discussion of the therapeutic application of mineral waters does not come within the scope of the present article. It is a medical question and lies without the province of the geologist or economist. The mineral-spring resorts of the country have never been very thoroughly studied from a statistical point of view, although there is scarcely a state in the Union that has not its mineral spring resorts, even if only locally important, or its sanitaria erected usually in connection with mineral springs. Many springs are utilized both as resorts and as sources of water for commercial purposes.

LIST OF AMERICAN MINERAL SPRING RESORTS.

ALABAMA.

Bailey springs.
Bladen springs.
Blount mineral springs.
Butler springs.
Chandler's springs.
Cullom's springs.
Healing springs.

ARIZONA.

Castle Creek springs.
Hooker's hot springs.

ARKANSAS.

Hot springs.
Cluster springs.
Eureka springs.
Dove Park springs.
Fairchild's potash sulphur springs.
Mountain Valley springs.

CALIFORNIA.

Adams springs.
Ætna springs.
Aguade Vida springs.
Alum rock springs, near San Jose.
Anderson mineral springs.
Byron hot springs.
California seltzer springs.
Campbell's hot springs.
Coronado mineral springs.
El Paso de Robles springs.
Felts mineral spring.
Fulton wells.
California geysers.
Geyser spa spring.
Litton seltzer spring.
Gilmore Glen spring.
Gilroy hot springs.
Glen alpine springs.
Gordon's mineral springs.
Harbin springs.
Highland springs.
Howard springs.
Klamath hot springs.
Lane's mineral spring.
Carnelian hot springs.
Madrone mineral springs.
Mark West springs.
Matilija hot springs.
Monticeto hot springs.
Napa soda springs.
Newsome's Arroyo Grande springs.
Paraisa spring.
Pacific congress springs.
Piedmont white sulphur springs.
Rubicon soda springs.
San Bernardino hot springs.
Santa Barbara hot springs
Santa Rosa springs.
Santa Ysabel springs.
Seigler's springs.
Skaggs' hot springs.
Summit soda springs.
Tuscan springs.
Tolenas springs.
Upper soda springs.
Ukiah vichy springs.
Upper soda springs, Siskiyou County.
Saint Helena white sulphur springs.
Witters' springs.
Wilbur springs.

COLORADO.

Douglas springs.
Canyon City springs.
Siloam springs.
Idaho springs.
Poncho springs.
Ouray mineral springs.
Manitou springs.
Liberty hot springs.
Rock Creek springs.
Trimble springs.
Steamboat springs.
Glenwood springs.
Pagosa springs.
Seltzer mineral springs.
Hot springs of Middle Park.
Cottonwood springs.
Heywood springs.
Mineral springs of Pueblo.

CONNECTICUT.

Stafford mineral springs.
Oxford chalybeate spring.

FLORIDA.

Magnolia springs.
Turner springs.
Orange springs.
Tarpon springs.
Benson's salt springs.
Wakulla spring.
Green Cove springs.
Blue springs.
Newport sulphur springs.
Wesson's iron springs.
Suwannee sulphur springs.
White sulphur springs.

GEORGIA.

Beall's springs.
Daniels' mineral spring.
Franklin springs.
Bowden lithia springs.
Chalybeate springs.
New Holland springs.
White sulphur springs.
Watson's springs.
Porter's springs.
Catoosa springs.
Hughes mineral springs.
Indian springs.
Magnolia springs.
Warm springs.
Powder springs.

IDAHO.

Ahlfor's springs.
Elliott's springs.
Easbly springs.
Hailey hot springs.
Guyer hot springs.
Soda springs.

ILLINOIS.

Alcyone springs.
Glen Flora springs.
Silver spring.
Diamond mineral spring.
Green Lawn springs.
Peoria magnetic artesian well.
Kirkwood springs.
Perry springs.
Hygienic western Saratoga springs.
Illinois lithia springs.
Moonlawn springs.
Okawville mineral spring.

INDIANA.

Ash iron springs.
Cameron springs.
French Lick springs.
Hosea saline sulphur springs.
Trinity springs.
Lithium springs.
Avoca springs.
West Baden springs.
Central springs.
Greencastle springs.
Saint Ronan's well.
Spring Beach springs.
Kickapoo magnetic mineral springs.
Cartersburg magnetic springs.

IOWA.

Ottumwa mineral springs.
Cherokee magnetic mineral springs.
Black Hawk mineral springs.
Lake View medical springs.
Linwood springs.
Siloam springs.
White sulphur springs.

KANSAS.

Iola mineral well.
Blaging's artesian mineral springs.
Arlington mineral springs.
Great Spirit springs.
Jewell County lithia springs.
Geuda springs.
Mound Valley springs.
Providence mineral well.
Topeka mineral wells.
Wichita mineral springs.
Louisville springs.

KENTUCKY.

Anita springs.
Allen springs.
Bedford springs.
Blue Lick springs.
Crab Orchard Springs.
Cerulean springs.
Forrest springs.
Drennon springs.
Buena Vista springs.
Hardin springs.
Kentucky alum springs.
Rock Castle springs.
Saint Patrick's well.
White sulphur springs.

LOUISIANA.

De Soto mineral springs.
White sulphur springs.
Abita springs.
Chiuchula spring.
Castor sulphur springs.
Ocean springs.
Claiburn spring.

MAINE.

Addison mineral springs.
American chalybeate springs.
Auburn mineral springs.
Barker mill spring.
Cold Bowling spring.
Hartford cold spring
Lake Auburn mineral spring.
Lubec saline spring.
Keystone spring.
Old Point Indian spring.
Poland spring.
Rosicrucian springs.
Seal Rock springs.
Scarborough mineral spring.
Underwood springs.
Wilson springs.

MARYLAND.

Bentleys springs.
Carroll springs.
Chattolanee mineral springs.
Flintstone mineral springs.
River springs.
Spa spring.
Strontia mineral spring.
Takoma park spring.
Windsor sulphur springs.

MASSACHUSETTS.

Allandale springs.
Beckster soda springs
Bethlehem spring.
Belmont Hill springs.
Belmont natural springs.
Commonwealth mineral springs.
Echo grove spring.
Everett crystal spring.
Sheep rock springs.
Simpson spring.
Undine spring.
Vishnu springs.

MICHIGAN.

Alpena mineral well.
Americanus well.
Cascade spring.
Eastman springs.
Butterworth magnetic spring.
Eaton Rapids magnetic springs.
Bethlehem magnetic mineral springs.
Erie sulphur springs.
Flints magnetic springs.
Grand Haven mineral spring.
Hubbardston magnetic well.
Leslie magnetic well.
Midland magnetic well.
Mount Clemens original mineral spring.
Moorman well, Ypsilanti.
Otsego mineral springs.
Riverside mineral spring.
Salutaris springs.
Sprudel well.
Spring Lake mineral springs.
Shawnee mineral springs.
Saint Clair mineral springs.
Saint Louis magnetic spring.
Zauber Wasser springs.
Ypsilanti mineral springs.

MINNESOTA.

Geissinger springs.
Inglewood spring.

MISSISSIPPI.

Artesian springs.
Belmont spring.
Brown's wells.
Castalian springs.
Godbolds mineral well.
Juka mineral springs.
Lafayette springs.
Stafford mineral springs.
White's springs.
Winston springs.

MISSOURI.

Arkoe springs.
Blankenship medical springs.
Blue Lick springs.
Belcher's artesian well.
Boon's Lick springs.
B. B. springs.
Barnard mineral well.
Clinton artesian white sulphur well.
Denver mineral spring.
Eldorado springs.
Elk Lick springs.
Electric springs.
Excelsior springs.
Fair Haven springs.
Fair View springs.
Forest springs.
Greenwood springs.
Greene springs.
Haupt's mineral well.
Glasgow mineral springs.
Harris springs.
Jordan artesian well.
Indian springs.
Jamesport mineral springs.
Jerico springs.
Lanandreths springs.
Lebanon springs.
Landreth's mineral well.
Monegaw springs.
Montesano springs.
Moundsville mineral springs.
McAllester springs.
Paris springs.
Randolph springs.
Reiger springs.
Reed springs.
Rogers springs.
Spaulding springs.
Siloam springs.
Sweet springs.
Windsor medical spring.
Young's medical well.
Vichy springs.
Panacea springs.

MONTANA.

Alhambra springs.
Allan's mineral springs.
Boulder hot springs.
Ferris' hot springs.
Helena hot springs.
Hunter's hot springs.
Lou Lou hot springs.
Mill Creek Apollinaris spring.
Puller's springs.
Pipestone springs.
Warm springs, Deer Lodge valley.
White sulphur springs.
Ryan's hot springs.

NEBRASKA.

Victoria mineral spring.

NEW HAMPSHIRE.

Amherst soda springs.
Birchdale springs.
Bradford mineral spring.
Londonderry lithia spring.
Ponemah springs.
Unity springs.
White Mountain spring.
Yacum springs.

NEW JERSEY.

Kolium springs.
Spa spring.
Schooly's Mountain spring.
Warwick spring.

NEW MEXICO.

Hudson hot springs.
Ojo Caliente.
Baca springs.
Jemes hot springs.
Aztec springs.
Coyote soda springs.
Las Vegas springs.

NEW YORK.

Adirondack mineral springs.
Avon sulphur springs.
Ballston Spa springs.
Cairo white sulphur springs.
Cayuga springs.
Crystal springs.
Columbia springs.
Chittenango white sulphur springs.
Clifton springs.
Dansville springs.
Deep rock springs.
Darien mineral spring.
Dryden springs.
Doxtater's mineral well.
Excelsior spring and Chlorine spring, Syracuse.
Florida springs.
Franklin springs.
Lebanon thermal spring.
Nunda mineral springs.
Oak Orchard acid springs.
Oneita springs.
Richfield springs.
Saratoga springs.
Sharon springs.
Slaterville magnetic springs.
Miller's Geneva mineral spring.
Verona mineral springs.
Victor sulphur springs.
Massena springs.
Ried springs.
Empire Seneca spring.

NORTH CAROLINA.

All-healing springs.
Ashleys bromine and arsenic springs.
Barium springs.
Black Mountain iron and alum spring.
Cherokee springs.
Cleveland spring.
Creswell's white sulphur spring.
Ellerbe springs.
Blackwell's white sulphur spring.
Haywood white sulphur springs.
Jackson springs.
Lemon springs.
Lincoln lithia springs.
Millenheimers sulphur springs.
Minnekahta springs.
Panacea springs.
Parks alkaline springs.
Piedmont spring.
Seven springs.
Shaws healing springs.
Thompsons bromine arsenic spring.
Mount Vernon mineral spring.

OHIO.

Adams county mineral spring.
Bellbrook magnetic spring.
Crystal mineral spring.
Cedar springs.
Devonian mineral spring
Electro-magnetic springs.
Lenape spring.
Howland springs.
Knisely's springs.
Greene mineral spring.
Magnetic and saline spring.
Marquis mineral spring.
Ohio magnetic springs.
Rex mineral water.
Ripley bromo lithia spring.
Stryker mineral well.
Sulphur Lick spring.
Sulphur spa.
Williamsport sulphur spring.
Yellow springs.

OREGON.

Belknap hot springs.
Foley springs.
MacAlister's soda springs.
Sodaville springs.
Wagner soda spring.
Wilhoit spring.

PENNSYLVANIA.

Allegheny spring.
Bedford springs.
Black barren Mineral spring.
Blossburg springs.
Carlisle White Sulphur spring.
Corry artesian fountain.
Cresson springs.
Doubling Gap springs.
Ephrata spring.
Eureka mineral springs.
Frankfort springs.
Gettysburg Katalysine spring.
Kingsland spring.
Minnequa springs.
Parker's magnetic mineral spring.
Pavilion spring.
Perry county warm spring.
Pulaski mineral spring.
Roscommon springs.
Saltillo springs.
Sizerville magnetic spring.
Susquehanna spring.
Wildwood springs.
Yellow springs.
York sulphur spring.

RHODE ISLAND.

Darling's mineral spring.
Holly springs.
Ochee mineral and medical springs.

SOUTH CAROLINA.

Ambler's mineral spring.
Charleston artesian well.
Cherokee springs.
Chick's springs.
Garrett springs.
Glen springs.
New springs, near Spartanburg.
Reedy creek springs.
West springs.

SOUTH DAKOTA.

Dakota hot springs.
Wessington springs.

TENNESSEE.

Alleghany springs.
Austin springs.
Beersheba springs.
Black sulphur springs.
Bon Aqua springs.
Cascade springs.
Castalian springs.
Clarkstown springs.
Dandridge springs.
Draper springs.
Estill springs.
Galbraith springs.

Glover's springs.
Graham's springs.
Hager springs.
Hinson springs.
Howard springs.
Idaho springs.
Jordan's springs.
Klippert's springs.
Melrose springs.
Mineral Hill springs.
Montvale springs.
Nashville sulphur springs.
Oliver's springs.
Park's sulphur spring.
Patterson's springs.
Pettigrews springs.
Primm's springs.
Red boiling springs.
Rhea springs.
Tate's Epsom spring.
Wayland springs.
White Cliff springs.
White creek spring.
White sulphur spring.

TEXAS.

Bell mineral well.
Boston chalybeate spring.
Burdetts sour wells.
Capp's well.
Dalby springs.
Duffau's wells.
Elkhart mineral wells.
Georgetown mineral wells.
Glenmore sulphur springs.
Hancock springs.
Hughes springs.
Hynson's Iron mountain springs.
Mineola mineral wells.
Mineral wells.
Montvale springs.
Overall mineral well.
Page's well.
Richards wells.
Roxboro springs.
Sharp's springs.
Slack's well.
Sulphur springs.
Texas sour springs.
Tioga mineral well.
Wisner's springs.
Wooten wells.

VERMONT.

Albaugh sulphur and lithia spring.
Brunswick white sulphur springs.
Clarendon springs.
Guilford springs.
Highgate springs.
Middletown mineral springs.
Missisquoi mineral spring.
Montebello springs.
Plainfield spring.
Weldon spring.
Wolcot springs.

VIRGINIA.

Alleghany springs.
Bath alum spring.
Bear lithia springs.
Buckingham white sulphur springs.
Buffalo lithia springs.
Cedar Bluff springs.
Chase City chlorine spring.
Chilhowie sulphur springs.
Clifton springs.
Cold sulphur springs.
Cove lithia water.
Coyner's sulphur springs.
Elk lithia springs.
Farmville lithia springs.
Grayson sulphur springs.
Harris antidyspeptic and tonic spring.
Healing springs.
Hot springs.
Huguenot springs.
Hunter's Pulaski alum springs.
Jordan alum springs.
Jordan white sulphur spring.
Kimberling springs.
Massanetta springs.
Millboro springs.
Osceola springs.
Otterburn lithia springs
Paeonian springs.
Powhatan springs.
Rawley springs.
Roanoke red sulphur springs.
Rockbridge alum springs.
Rockbridge baths.
Rock Enon springs.
Rockingham springs.
Seven springs.

Sharon springs.
Shenandoah alum springs.
Stafford springs.
Steep Hill springs.
Stribling springs.
Sweet chalybeate springs.
Valley View springs.
Virginia arsenic bromine and lithia springs.
Wallawhatoola alum springs.
Washington springs.
Wolf Trap lithia springs.
Yellow springs.

WASHINGTON.

Cascade springs.
Medical lake.
Yakima soda springs.

WEST VIRGINIA.

Berkeley springs.
Blue sulphur springs.
Capon springs.
Columbia sulphur spring.
Floding springs.
Greenbrier white sulphur springs.
Hart mineral well.
Irondale springs.
Parkersburg mineral well.
Red sulphur springs.
Salt sulphur springs.
Shannondale springs.
Sweet springs.
Triplett springs.

WISCONSIN.

Allouez magnetic springs.
Almanaris springs.
Arcadian springs.
Arctic springs.
Ashland springs.
Bethania mineral spring.
Bethesda spring, Waukesha.
Black Earth mineral spring.
Clysmic spring, Waukesha.
Crescent spring, Waukesha.
Darlington mineral spring.
Fort Crawford spring.
Fountain spring, Waukesha.
Gihon springs.
Glen spring, Waukesha.
Heuk mineral spring.
Horeb mineral spring, Waukesha.
Hygeia spring, Waukesha.
Iodo magnesian springs.
Jacobs artesian well, Milwaukee.
Lebenswasser spring.
Lethian spring, Waukesha.
Mineral Rock spring, Waukesha.
Nee-ska-ra spring.
New Saratoga spring.
Palmyra springs.
Saint Croix mineral spring.
Salvator springs.
Shealtiel mineral springs.
Sheboygan mineral spring.
Sheridan springs.
Siloam spring, Waukesha.
Silver Sand spring.
Sparta mineral wells.
Vesta spring, Waukesha.
Vita mineral spring.
White Rock spring, Waukesha.